

**Geologic Resources Inventory Workshop Summary**  
**Zion National Park, Utah**  
***April 12-13, 1999***

**National Park Service**  
***Geologic Resources Division***  
***and***  
***Natural Resources Information Division***

Version: Revised Draft of April 27, 1999

**EXECUTIVE SUMMARY**

An inventory workshop was held at Zion National Park on April 12-13, 1999 to view and discuss the park's geologic resources, to address the status of geologic mapping by both the Utah Geological Survey (UGS) and the United States Geological Survey (USGS) for compiling both paper and digital maps, and to assess resource management issues and needs. Cooperators from the NPS Geologic Resources Division (GRD), Natural Resources Information Division (NRID), Zion NP (interpretation), UGS, USGS, Utah Geological Association (UGA) and Utah Bureau of Land Management (BLM) were present for the two day workshop. ([see Appendix A, Zion NP Geological Resources Inventory Workshop Participants, April 12-13, 1999](#))

Day one involved a field trip led by UGS geologists Grant Willis and Helmut Doelling. Highlights of the field trip included visits to view paleontological resources within the Triassic Moenave Formation (*Whitmore Point Member*) where dinosaur track sites exist near the visitor center area, the Birch Creek landslide-dammed lake deposits, Crater Hill volcanic deposits, and the structural geology of the Hurricane fault zone and Kannarraville anticline. The field trip was concluded with a "team building" session (barbecue) at USGS Geologist Pete Rowley's new home in New Harmony, UT.

[An on-line slide show of the highlights of the field trip can be found at http://www.nature.nps.gov/grd/geology/gri/ut/zion/field\\_trip\\_zion](http://www.nature.nps.gov/grd/geology/gri/ut/zion/field_trip_zion)

Day two involved a scoping session to present overviews of the NPS Inventory and Monitoring (I&M) program, the Geologic Resources Division, and the ongoing Geologic Resources Inventory (GRI) for Colorado and Utah. Round table discussions involving geologic issues for Zion NP included interpretation, the UGA Millennium 2000 guidebook featuring the geology of Utah's National and State parks, paleontological resources, the status of cooperative geologic mapping efforts, sources of available data, geologic hazards, potential future research topics, and action items generated from this meeting. Brief summaries of each follows.

## **Zion NP GRI Workshop Summary: April 12-13, 1999 (cont'd)**

### **OVERVIEW OF GEOLOGIC RESOURCES INVENTORY**

After introductions by the participants, Joe Gregson (NPS-NRID) presented an overview of the NPS I&M Program, the status of the natural resource inventories, and the geological resources inventory ([see Appendix B, Overview of Geologic Resources Inventory](#)).

He also presented a demonstration of some of the main features of the **digital geologic map** for the Black Canyon of the Gunnison NM and Curecanti NRA areas in Colorado. This has become the prototype for the NPS digital geologic map model as it ideally reproduces all aspects of a paper map (i.e. it incorporates the map notes, cross sections, legend etc.) with the added benefit of being a GIS component. It is displayed in ESRI ArcView shape files and features a built-in help file system to identify the map units. It can also display scanned JPG or GIF images of the geologic cross sections supplied with the map. The cross section lines (ex. A-A') are subsequently digitized as a shape file and are hyperlinked to the scanned images.

***For a recap on this process, go to: [http://www.nature.nps.gov/grd/geology/gri/blca\\_cure/](http://www.nature.nps.gov/grd/geology/gri/blca_cure/) and view the various files in the directory.***

The geologists at the workshop familiar with GIS methods were quite impressed with this method of displaying geologic maps digitally; Gregson is to be commended for his accomplishments.

Bruce Heise (NPS-GRD) followed with a presentation summary of the up-to-date results of the Colorado GRI program. The status of each park area for geologic mapping inventories, digitizing maps, assembling bibliographies, preparing reports and defining deliverable dates for the NPS units in Colorado was discussed, as the Utah parks will follow a similar process.

### **INTERPRETATION**

The GRI also aims to help promote geologic resource interpretation within the parks and GRD has staff and technology to assist in preparation of useful materials including developing site bulletins and resource management proposal (RMP) statements appropriate to promoting geology. Jim Wood (GRD) and Melanie Moreno (USGS-Menlo Park, CA) have worked with several other NPS units in developing web-based geology interpretation themes, and should be considered as a source of assistance should the park desire.

Zion interpreters pointed out that the park's newspaper has an excellent article summarizing some aspects of the park's stratigraphy. Also, the park's program entitled "*Sedimentary my dear Watson*" was illustrated as an example of a successful interpretation program in a park that treats geology.

Zion interpreters said their goal is to educate the public that geology is not boring. A significant GPRA (government performance and results act) goal for the park is that

## **Zion NP GRI Workshop Summary: April 12-13, 1999 (cont'd)**

97% of visitors will be able to understand some aspects of the geology, and thus there is an emphasis on simplifying the geology for visitors. To aid in this process, more graphics and brochures related to the geology are desirable and should target the average enthusiast. These could be either black and white or full color (similar to the park's main brochure). It was also noted that supplies of such produced material should be always stocked instead of distributed once in a single mass printing.

It was also noted that the appropriate time to promote geology and convey a geologic message with the visitor is at the time of their visiting experience when they are most receptive to learning, not a week later. This may involve trying to get them to concessions to purchase materials relevant to the geology so that they can further their interest.

Tom Haraden (Zion NP) discussed how interpreters reach the general public. He believes most park visitors want to be around rangers and interpreters when they come to the area. The park has an environmental education person working to educate teachers on the geology so that when they bring their groups in, the teacher becomes the knowledgeable "hero" instead of the park staff. To this means, the park will provide props and other learning materials to facilitate this. Also, the new visitor center will feature a 90-second video display on the geology of the park. This should probably be quality assured/ quality controlled (QA/QC'd) by interpretive staff and geologists for accuracy prior to release. Several wayside exhibits are also planned to emphasize the geology so that the common person can discover geology on their own.

Common questions asked of interpreters that involved geology include the following:

- When is the next rockfall?
- Are the rocks monitored for falls?
- What is responsible for the colors of the rocks?

From an ecosystem management perspective, Zion is at the confluence of important physiographic provinces (Basin and Range and Colorado Plateau), making a case for it as the NPS "poster-child" for promoting the ecosystem management concept. It is a spectacular place to integrate geology with biology, hydrology, geomorphology, vegetation and many other facets of the ecosystem. Flood awareness is also a major theme of interpretation; April 1999 was "Flood Awareness Month" at the park and the staff are sure to warn visitors of the potential for danger from this geologic process.

### **UGA GUIDEBOOK ON UTAH'S NATIONAL AND STATE PARK AREAS**

Doug Sprinkel of the UGA announced that a guidebook treating the geology of 27 of Utah's national and state parks and monuments will be compiled for publication in September 2000. This compilation will be a snapshot into the geology of each park and covers most facets of what the GRI is trying to develop for each park for a final report (i.e. cross sections, simplified geologic map, general discussions of rocks, structure, unique aspects of park geology, classic viewing localities). Each author will be *encouraged* to get with NPS staff interpreters to develop a product that aims at a wide audience (the common visitor, the technical audience and the teaching community).

## **Zion NP GRI Workshop Summary: April 12-13, 1999 (cont'd)**

Zion NP authors will be our field trip leaders from the UGS (Grant Willis and Helmut Doelling).

Also, a CD-ROM will be distributed with the publication featuring road and trail logs for specific parks as well as a photo glossary and gallery. The photo glossary will describe certain geologic features (i.e. what is crossbedding?). These will also be available as web-downloadable Adobe Acrobat PDF files. The UGA cannot copyright this material because it is funded with state money, so it can be distributed widely and freely, which will also benefit the purposes of the GRI. Additional reprints are not a problem because of the digital nature of the publication and the UGA board is committed to additional printings as needed. UGA normally prints 1000 copies of their publications because they become dated after about five years; that will probably not be an issue for this publication. Prices for the full-color guidebook are estimated to be approximately \$25/copy, and sales are expected to be high (exact estimates for Capitol Reef NM were 125 copies/year). A website for the guidebook is forthcoming in October 1999.

Field Trips will be held in September 2000. Currently, four field trips are scheduled:

1. Arches NP, Canyonlands NP, Dead Horse Point State Park (SP)
2. Antelope Island SP and Wasatch Mountain SP
3. Zion NP, Cedar Breaks NM, Snow Canyon SP and Quail Creek SP
4. Dinosaur NM, Flaming Gorge NRA, and Red Fleet SP

*Note: Trips 1 and 2 will run concurrently and Trips 3 and 4 will also run concurrently.*

Many other benefits are anticipated from this publication and are enumerated below:

- This type of project could serve as a model for other states to follow to bolster tourism and book sales promoting their state and its geologic features.
- Sandy Eldredge (UGS) will be targeting teaching communities for involvement in the field trips; hopefully teachers will pass on what they have learned to their young audience.
- The language is intended to appeal to someone with a moderate background in geology and yet will be very informative to the educated geologist.
- The publication may be able to serve as a textbook to colleges teaching Geology of National Parks (in Utah).
- A welcomed by-product could be roadlogs between parks in Utah for those visiting multiple parks, perhaps with a regional synthesis summarizing how the overall picture of Utah geology has developed.

### **PALEONTOLOGICAL RESOURCES**

The field trip provided glimpses into the little known paleontological resources of dinosaur trackways near the visitor center. Intern Joshua Smith has been locating and studying the tracks and will be giving a summary of his findings to the Zion interpretive

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staff in the near future. It has been suggested to keep these locations low profile to minimize disturbances and potential theft or vandalism.

Vince Santucci (NPS-GRD Paleontologist) will be co-authoring a "*Paleontological Survey of Zion National Park*" with Josh and detailing their findings of resources within the park. Plants, invertebrates, and vertebrate tracksites are among the recognized paleontological resources within the Zion area.

Similar surveys have been done for Yellowstone and Death Valley NP's and have shed valuable new information on previously unrecognized resources. These surveys involve a literature review/bibliography and recognition of type specimens, species lists, and maps (which are unpublished to protect locality information), and also make park specific recommendations for protecting and preserving the resources.

The Death Valley Survey will be available soon. The **Yellowstone** Survey is already available on-line at:

[http://www.nature.nps.gov/grd/geology/paleo/yell\\_survey/index.htm](http://www.nature.nps.gov/grd/geology/paleo/yell_survey/index.htm)

and is also available as a downloadable PDF at

<http://www.nature.nps.gov/grd/geology/paleo/yell.pdf>

Paleontological resource management plans should be produced for Zion involving some inventory and monitoring to identify human and natural threats to these resources. Perhaps someone on the park staff could be assigned to coordinate paleontological resource management and incorporate any findings or suggestions into the parks general management plan (GMP). It would be useful to train park staff (including interpreters and law enforcement) in resource protection, as the fossil trade "black market" has become quite lucrative for sellers and often results in illegal collecting from federal lands.

Collections taken from this area that now reside in outside repositories should be tracked down for inventory purposes. Fossils offer many interpretive themes and combine a geology/biology link and should be utilized as much as possible in interpretive programs.

### STATUS OF COOPERATIVE GEOLOGIC MAPPING EFFORTS FOR ZION NP

#### **UGS Perspective**

Currently, the UGS is mapping in Utah at three different scales:

- **1:24,000** for high priority areas (i.e. National and State parks)
- **1:100,000** for the rest of the state
- **1:500,000** for a compiled state geologic map

The availability of funding for Zion (jointly with the NPS) has made it possible for these higher priority areas to be mapped at this detail. The UGS plans to complete mapping for the entire state of Utah within 10-15 years at 1:100,000 scale. For **1:100,000** scale maps, their goal is to produce *both* paper and digital maps; for **1:24,000** scale maps, the

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only digital products will be from "special interest" areas (i.e. areas such as Zion and growing metropolitan St. George). Grant Willis mentioned that the UGS simply does not have enough manpower and resources to do more areas at this scale. He also reiterated that UGS mapping goals are coincident with those of the National Geologic Mapping Program.

In Zion NP, the UGS has been jointly cooperating with the NPS and USGS for some time on producing these 1:24,000 quadrangles in both paper and digital format. Until 1995, the USGS had done major mapping projects under the BARCO (Basin and Range to Colorado Plateau) mapping program. When the USGS reorganized, many of these projects were put on indefinite hold. Fortunately, there has been mutual cooperation between the UGS and USGS to work together to get these products completed for the NPS. The NPS appreciates the labor of all involved parties and individuals in this cooperative and hopes that many products will result from the combined efforts of all involved agencies.

The UGS has divided their mapping work in Zion into two distinct phases. The **first phase** involves producing geologic maps for the following quadrangles ([see Appendix C, Zion NP Index of Geologic Maps, 1:24,000 Scale](#)):

- **The Guardian Angels**
- **Temple of Sinawava**
- **Clear Creek Mountain**
- **Springdale West**
- **Springdale East**

All five quadrangles are field mapped and are presently in the internal review stage by the UGS; some field spot-checking is desirable. Some of the mapping was done using photogrammetric methods and some is hand drawn on Mylar. The UGS expects to deliver *both* completed paper and digital products **by October 1, 1999**. The original projected deliverable date was April 1, 1999, however, the UGS has had significant turnover with their GIS personnel and has requested an extension until October 1<sup>st</sup>.

The **second phase** is beginning in spring 1999. This will involve geologic mapping for the following quadrangles:

- **Kolob Arch**
- **Kolob Reservoir**
- **Cogswell Point**
- **Completion of Smith Mesa, The Barracks, and Navajo Lake**

This phase will also involve completing the **Smith Mesa** quadrangle. Ed Sable (USGS) was the primary worker on this map but was unable to complete it due to health problems. The USGS and UGS are working cooperatively to get make sure this product is completed. **The Barracks** (southeast Zion NP) and **Navajo Lake** (south Cedar Breaks NM) are already available as published paper maps and will be digitized as part of this phase. Deliverable dates for this phase should be **September 2001** according to

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Grant Willis. Upon completion of this phase, there will be complete digital coverage for Zion NP.

Some issues have surfaced regarding the correlation of Quaternary deposits across quadrangle boundaries which has caused some delay in matching edges between maps of the USGS BARCO project and those of the UGS. The UGS would like to treat these deposits more in-depth.

### ***USGS Perspective***

Pete Rowley (USGS) talked about the immense scope of the BARCO project for preparing 1:100,000 scale maps for earthquake potential, mineral resources and various other themes. Mapping was done at 1:24,000 scale and compiled at 1:100,000 scale. Unfortunately, this project was put on the backshelf because of the USGS 1995 reorganization and many of the original workers have not been able to realize final products for their previous mapping efforts.

The UGS has essentially inherited much of Ed Sable's work in the Zion area since health problems wouldn't allow him to continue working in the field. Since the USGS requires digital geologic maps for all of their work, Pete is working with Southern Utah University's (SUU) Dave Maxwell to complete digitizing for Ed's BARCO work. It seems like the UGS has the Zion area well in hand, so Pete's energies will be focused on deliverables for the Bryce Canyon and Cedar Breaks areas.

USGS assistance is most welcomed in completing quadrangles in the vicinity of Zion, Cedar Breaks, and Bryce Canyon because the UGS does not have personnel currently assigned to work in these areas. Both the USGS and UGS agree that the main priority is to get these BARCO products into usable forms and give credit where credit is due. The following quadrangles were mentioned as either being partially mapped or important to the regional watershed:

- **Straight Canyon**
- **Flanigan Arch**
- **Webster Flat**
- **Mount Carmel**
- **Glendale**
- **Orderville**
- **Long Valley Junction**
- **North**
- **Strawberry Point**
- **Alton**
- **Yellow Jacket Canyon**
- **Elephant Butte**
- **Hilldale**
- **Cedar Mountain**
- **Kannarraville**
- **Smithsonian Butte**



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While these quadrangles are not necessarily within an NPS boundary, they are part of the regional watershed and would be welcomed products by the NPS. Bob Higgins suggests trying to get NPS Water Resources Division (WRD) to help fund some of the mapping since the bedrock geology is already available and since these involve the watershed.

As the park's hydrologist, Dave Sharrow would like to see some emphasis on studying the quadrangles east of Zion for water issues. From his perspective those closest to the Sevier fault are of most interest to him because of a lack of understanding of the hydrology nearest the fault. Pete has done a similar type of project for Nevada test site and would be willing to further discuss this with Dave Sharrow.

### **There are some financing issues to consider in completing these quadrangles:**

- Pete would need some financial assistance in digitizing these maps at SUU
- An EDMAP project may be a good way to obtain assistance for completing any needed field mapping with SUU students
- Pete's salary and time needs to be covered by the USGS to work on this project
- Other surficial specialists (*Van Williams was mentioned*) may need to be called upon to help complete the surficial mapping and caliche deposits; also numerous landslides are known for the area and should be mapped appropriately. Salary and time is also an issue for these specialists.

A priority list for quadrangles of interest should be developed for SUU and estimates of costs to complete the work also need to be ascertained.

### **OTHER SOURCES OF NATURAL RESOURCES DATA FOR ZION NP**

- The UGS has a significant quadrangle database that they have furnished to NRID for the entire state of Utah.
- NRID has compiled a geologic bibliography for numerous parks and monuments, including Zion. Visit the website at: <http://165.83.36.151/biblios/geobib.nsf>; user id is "geobib read", password is "anybody".
- The USGS has compiled large volumes of data on the BARCO project that was halted in 1995; much of this work is unpublished and should be sought out from USGS personnel.
- It was suggested that the DOE may have mineral exploration data for the area as there are numerous mineral resources within the park (copper, iron, uranium, silica, cinders, gravels, coal, as well as hydrocarbon potential).
- A STORET water quality report apparently exists and may be available from the NPS-WRD.



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- Wayne Hamilton's 1987 **geologic map** is digitized because years ago park staff needed a geologic layer for their GMP to define use areas within the park. However, it is expected that the new layers provided by the UGS will make this existing coverage obsolete.
- A **soils** map apparently exists for the park but could use significant improvement. It contains adequate soil descriptions, but according to Laird Naylor boundaries are poor. It was suggested that the new geology layers can enhance the existing understanding of the soils by comparing layers.
- Both an **Archeological** and **Paleontological** (from Josh Smith) database apparently exist, but there is no metadata, rendering it incomplete. Proposed coverages include a layer for **floodplains**, **geologic hazards**, and **debris flow paths**.
- It was rumored that the park may also have a **disturbed land sites** database featuring many small dams (up to a few acres). It was suggested that GRD begin compiling and tracking this information for their disturbed lands programs as it is a component of the GRI. Suggested park contacts for this database were Laurie Kurth and Darla Sidles. GRD's Disturbed Lands coordinator (Dave Steensen) may want to attempt to contact these folks and obtain any available data.
- Other disturbed land related issues included exotic species and channelization along the river. The river restoration debate involves whether the river should be allowed to run its course. Restoring the stream channel to its natural position is identified in the GMP, and will likely be a very expensive endeavor.

### GEOLOGIC HAZARDS

There are numerous issues related to geologic hazards in and around Zion NP. Below is a brief list of some mentioned during the scoping session:

- Landslides of **April 1995**, **1923**, **1941**, and **September 11, 1998** that resulted in taking out the park road to the Zion Lodge
- many active landslides are in the park on North Creek with the potential to dam creek and create lake (i.e. above Sunset Ridge headquarters at edge of park boundary)
- a few years ago, from the Kolob Canyon section, portions of Interstate-15 was washed over and vehicles were actually washed off of the road (this was pointed out to us during the field trip) because of a landslide from a dam collapse
- 1992 earthquake scarp in Springdale at west entrance of park
- the Hurricane Fault marks the western boundary near the Kolob Canyon section of the park; the actual road is built essentially on the fault surface

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- the potential for volcanism exists within the Zion area
- debris flows and rockfalls are constant sources of problems during rainstorms
- collapsible soil potential from swelling soils within the Triassic Chinle Formation, and windblown loess deposits
- radon is known from soils developed upon the Chinle Formation
- abandoned mineral lands (AML) for uranium mining near the Kolob Canyon Visitor Center
- an existing oil well within park boundaries may pose the threat of mixing with groundwater and present a water quality breach
- it was suggested that any future facility siting exercises should focus near Crater Hill

### POTENTIAL RESEARCH TOPICS FOR ZION NP

A list of potential research topics includes studies of the following:

- Study the hydrology nearest the Sevier fault zone (east of Zion NP)
- Lake development and climate history
- Study Helmutt Doelling (UGS) core to bottom of lake deposits; take new core to bottom of deposits
- Lacustrine chronology from lake sediments
- History of slope instability from landslides (try to ascertain ages of landslides)
- Alluvial terrace chronology
- River system erosion history with emphasis on upstream basalts
- Fracture flow within the **Navajo Sandstone** because it is an important aquifer (*Pete has student Jonathan Cain doing post-doc work with USGS-WRD*)
- Study of Joints for ground-water quality/quantity
- Locations of hydrologic divides (where is the water going ?)
- History of Hurricane fault as related to Basin and Range extension

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- Geologic Type section for Navajo Sandstone within the park
- Vegetation type vs. rock type; what are the correlations
- Development of way to date desert varnish ages; (*Larry Snee will do it for \$500,000 ha ha.; Pete Rowley's wife has worked on similar projects; she is an archeologist*)
- Color in rocks due to cementation: Navajo groundwater and diagenesis creating color changes
- Paleobotanic investigations of various formations
- Study Pack-rat middens for ecological analysis
- Coal pit deposits
- History of joint formation
- Also, Tom Haraden should be consulted for his ideas on various interpretation and education topics; consult Wood and Moreno for assistance

### **ACTION ITEMS**

Many follow-up items were discussed during the course of the scoping session and are reiterated by category for quick reference.

#### **Interpretation**

- More graphics and brochures emphasizing geology and targeting the average enthusiast should be developed. If Zion NP needs assistance with these, please consult GRD's Jim Wood ([jim\\_f.wood@nps.gov](mailto:jim_f.wood@nps.gov)) or Melanie Moreno at the USGS-Menlo Park, CA ([mmoreno@usgs.gov](mailto:mmoreno@usgs.gov)).
- QA/QC of the new 90 second geology video for the new visitor center by geologic professionals for accuracy

#### **UGA Guidebook**

- Attempt to plant the seeds of this concept to other states for similar publications involving local area geology. Such publications are especially useful for the GRI

#### **Paleontological Resources**

- For now, try to minimize location disclosure of vertebrate tracksites to minimize disturbances and the potential for theft or vandalism
- Develop an in-house plan to inventory, monitor and protect significant paleontological resources from threats; assign staff to oversee

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- Locate collections taken from the park residing in outside repositories

### **Geologic Mapping**

- UGS deliver to NPS all Phase 1 products (paper and digital) by October 1, 1999
- UGS deliver to NPS all Phase 2 products (paper and digital) by September 2001
- Maintain UGS-USGS-NPS cooperation to reap all possible products from existing USGS BARCO work to benefit the NPS GRI
- Consult with NPS-WRD to obtain funding for mapping numerous quadrangles contained in regional watershed
- USGS address issues relating to funding salaries and other work to ensure BARCO products can be delivered
- USGS develop for SUU a priority list of quadrangles to digitize and complete field mapping, as well as associated estimates of time and material costs

### **Natural Resource Data Sources**

- Improve the soils map for Zion NP
- NPS-GRD Disturbed Lands Coordinator should consult with Zion staff about obtaining disturbed lands database

### **Miscellaneous**

- Laird Naylor suggested that Stan Hatfield, Robert Eves, and Fred Lohrengel (all of SUU) and Dave Madsen and Lee Allison (both UGS) should be invited to attend the Cedar Breaks NM meeting in July 1999
- Review proposed research topics for future studies within Zion NP

### **BUDGET ITEMS**

- The UGS has picked up 70% of the costs of mapping using State Map matching funds.
- NRID I&M paid \$79K in FY96 and \$59K in FY98 for a total buy-in of \$138K.

# APPENDIX A

## Zion NP Geological Resources Inventory Workshop Participants *April 12-13, 1999*

<b>NAME</b>	<b>AFFILIATION</b>	<b>PHONE</b>	<b>E-MAIL</b>	<b>Field Trip</b>	<b>Scoping Session</b>
Bruce Heise	NPS, Geologic Resources Division	(303) 969-2017	<a href="mailto:Bruce_Heise@nps.gov">Bruce_Heise@nps.gov</a>	x	x
Joe Gregson	NPS, Natural Resources Information Division	(970) 225-3559	<a href="mailto:Joe_Gregson@nps.gov">Joe_Gregson@nps.gov</a>	x	x
Tim Connors	NPS, Geologic Resources Division	(303) 969-2093	<a href="mailto:Tim_Connors@nps.gov">Tim_Connors@nps.gov</a>	x	x
Bob Higgins	NPS, Geologic Resources Division	(303) 969-2018	<a href="mailto:Bob_Higgins@nps.gov">Bob_Higgins@nps.gov</a>	x	x
Vince Santucci	NPS, Geologic Resources Division	(307) 877-4455	<a href="mailto:Vincent_Santucci@nps.gov">Vincent_Santucci@nps.gov</a>	x	x
Dave Sharrow	NPS, Zion NP	(435) 586-2765	<a href="mailto:Dave_Sharrow@nps.gov">Dave_Sharrow@nps.gov</a>	x	x
Laird Naylor	BLM (formerly Zion NP)	(801) 977-4357	<a href="mailto:Lnaylor@ut.blm.gov">Lnaylor@ut.blm.gov</a>	x	x
Larry Snee	USGS	(303) 236-5619	<a href="mailto:lsnee@usgs.gov">lsnee@usgs.gov</a>	x	x
Pete Rowley	USGS	(702) 897-4029	<a href="mailto:Prowley@usgs.gov">Prowley@usgs.gov</a>	x	x
Grant Willis	UGS	(801) 537-3355	<a href="mailto:Nrugs.gwillis@state.ut.us">Nrugs.gwillis@state.ut.us</a>	x	x
Helmuth Doelling	UGS			x	
Doug Sprinkel	UGS/UGA		<a href="mailto:sprinkel@vii.com">sprinkel@vii.com</a>	x	x
Kris Thompson	NPS, FOBU Paleontology intern	(307) 877-4455	<a href="mailto:Kmt65@altavista.net">Kmt65@altavista.net</a>	x	x
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Jeff Bradybaugh	NPS, Zion NP	(435) 772-0208	<a href="mailto:Jeff_Bradybaugh@nps.gov">Jeff_Bradybaugh@nps.gov</a>	x	x
Joshua Smith	NPS, Zion NP, Paleontology Intern	(435) 772-0223	<a href="mailto:Dinotrack@hotmail.com">Dinotrack@hotmail.com</a>	x	
Sonya Berger	NPS, Zion NP, Interpretation	(435) 772-1389			x
Tom Haraden	NPS, Zion NP, Interpretation	(435) 772-0161	<a href="mailto:Tom_Haraden@nps.gov">Tom_Haraden@nps.gov</a>		x

## **APPENDIX B**

### **Overview of Geologic Resources Inventory**

The NPS Geologic Inventory is a collaborative effort of the NPS Geologic Resources Division (GRD) and Inventory and Monitoring Program (I&M) with assistance from the U.S. Geological Survey (USGS), American Association of State Geologists (AASG), and numerous individual volunteers and cooperators at NPS units, colleges, and universities.

From the perspective of the servicewide I&M Program, the primary focus (Level 1) of the geological inventory is

1. to assemble a bibliography of associated geological resources for NPS units with significant natural resources,
2. to compile and evaluate a list of existing geologic maps for each unit,
3. to develop digital geologic map products, and
4. to complete a geological report that synthesizes much of the existing geologic knowledge about each park. The emphasis of the inventory is not to routinely initiate new geologic mapping projects, but to aggregate existing information and identify where serious geologic data needs and issues exist in the National Park System.

The NPS Geologic Resources Division is an active participant in the I&M Program and has provided guidance and funding in the development of inventory goals and activities. GRD administers the Abandoned Mine Lands (AML) and Geologists In Parks (GIP) programs which contribute to the inventory. NPS paleontologists, geologists, and other natural resource professionals also contribute to inventory planning and data. A major goal of the collaborative effort is to provide a broad baseline of geologic data and scientific support to assist park managers with earth resource issues that may arise.

For each NPS unit, a cooperative group of geologists and NPS personnel (the Park Team) will be assembled to advise and assist with the inventory. Park Teams will meet at the each NPS unit to discuss and scope the geologic resources and inventory, which is the subject of this report. If needed, a second meeting will be held at a central office to evaluate available geologic maps for digital production. After the two meetings, digital geologic map products and a geologic report will be produced. The report will summarize the geologic inventory activities and basic geology topics for each park unit. Due to the variety of geologic settings throughout the NPS, each report will vary in subject matter covered, and section topics will be adapted as needed to describe the geologic resources of each unit. Whenever possible the scientific sections of the report will be written by knowledgeable cooperators and peer reviewed for accuracy and validity.

# APPENDIX C

## Zion NP Index of Quadrangle Maps (1:24,000 scale)

